IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of:

Richard Liddy

Group Art Unit: 2113

Examiner: Michael C. Maskulinski

Serial No.: 10/707,186

Filed: November 25, 2003

For: METHOD TO FACILITATE FAILURE MODES AND EFFECTS ANALYSIS

Attorney Docket No.: 81087759 (FMC 1552 PUS)

DECLARATION UNDER 37 C.F.R. § 1.131

Mail Stop Amendment
Commissioner for Patents
U.S. Patent & Trademark Office
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

We, Richard Liddy, Bruce Maeroff, David Craig, Toni Brockers, Uwe Oettershagen, and Tim Davis, the inventors of the above-identified application hereby declare the following:

1. The subject matter recited in pending claims 1-20 was conceived of on or before June 18, 2003, as indicated in the email correspondence attached in Appendix A wherein the subject matter of the same, as noted by the corresponding draft specification included therein, was discussed with the Patent Attorney of record;

CERTIFICATE OF MAILING UNDER 37 C.F.R. § 1.8 (FIRST CLASS MAIL)

I hereby certify that this paper, including all enclosures referred to herein, is being deposited with the United States Postal Service as first-class mail, postage pre-paid, in an envelope addressed to: Mail Stop Amendment, Commissioner for Patents, U.S. Patent & Trademark Office, P.O. Box 1450, Alexandria, VA 22313-1450 on:

11-28-06	John R. Buser	
Date of Deposit	**Name of Person Signing**	**Signature**

2. The subject matter recited in pending claims 1-20 was diligently reduced to practice on July 5, 2003, from at least June 18, 2003, as indicated in the email correspondence attached in Appendix B wherein the a completed draft of the application was provided for inventor review;

3. We acknowledge that willful false statements and the like are punishable by fine or imprisonment, or both (18 U.S.C. § 1001) and may jeopardize the validity of the application or any patent issuing thereon;

4. We acknowledge that all statements made are of our own knowledge and are true and that all statements are made on information and belief believed to be true; and

5. We declare (or certify, verify, or state) under penalty of perjury.

Respectfully submitted,

Richard Liddy	**Toni Brockers,**
Richard G. Liddy 10-23-06	______________
Bruce Maeroff	**Uwe Oettershagen**
______________	______________
David Craig	**Tim Davis**
______________	______________

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Richard Liddy	**Toni Brockers,**
____________________	____________________
Bruce Maeroff	**Uwe Oettershagen**
____________________	____________________
David Craig	**Tim Davis**
David Craig 10/22/06	____________________

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Respectfully submitted,

Richard Liddy	**Toni Brockers,**
______________________	T. Brockers 19.10.2006
Bruce Maeroff	**Uwe Oettershagen**
______________________	______________________
David Craig	**Tim Davis**
______________________	______________________

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Bruce Maeroff	**Uwe Oettershagen**
Bruce Maeroff ______________________	______________________
David Craig	**Tim Davis**
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Respectfully submitted,

Richard Liddy **Toni Brockers,**

________________ ________________

Bruce Maeroff **Uwe Oettershagen**

________________ ________________

David Craig **Tim Davis**

________________ Timothy P Davis

8/3/06

From: "Maeroff, Bruce (B.J.)" <bmaeroff@ford.com>
To: <jbuser@brookskushman.com>
Date: 3/17/2003 3:26:19 PM
Subject: Version II

Please see what you think.

Bruce J. Maeroff
Manager, Campaign Prevention and Adv. Reliability
(313) 32-20518 bmaeroff
http://www.quality.ford.com/cpar

Background

Field of the Invention

The present invention relates to potential Failure Modes and Effects Analysis (FMEA). The FMEA incorporates robust linkages into a structured method for improved FMEA.

Background Art

Potential Failure Modes and Effects Analysis (FMEA) relates, in general, to a process used to determine the adequacy of current design and/or process and the need to mitigate risks by making changes to the design and/or current control process. FMEA relates to any number of industries and applications. Each industry and application may have separate standards and criterion for the control processes used therein.

In the automotive environment, SAE specification J1793 details a number of procedures, standards and criterion for automotive related FMEAs. J1739 defines FMEA as a systemized group of activities intended to: (a) recognize and evaluate the potential failure of a product/process, its effects and causes; (b) identify actions which could eliminate or reduce the chance of the potential failure occurring; and (c) document the process. It is complementary to the process of defining what a design or process must do to satisfy the customer.

J1739 fails to sufficiently compensate for the fact that new teams that write FMEAs need to fully define the system or what steps to take to define actions to be taken. More specifically, the current FMEA method overlooks the team learning necessary to define the boundy or the system, quantification of the interface with surrounding systems, the definition of inputs, outputs, control factors, noise factors, and error states all via a P diagram. The current FMEA methods also overlook after completion of the FMEA priortization and recommended actions summary vis a check list. Our research indicates many preventable failures and recalls can potentially be eliminated with the reduction or desensitising of such noise factors in product development.

Claims

A method for reducing field product failure due to the noise factors through potential Failure Modes and Effects Analysis (FMEA), the method comprising:

providing a boundary diagram, wherein the boundary diagram defines at least one relationship between at least two systems;

providing an interface matrix, wherein the interface matrix defines elements of each system, identifies interfaces between the at least two systems, categorizes each interface, and assigns a strength to each interface;

providing a p-diagram, wherein the p-diagram describes at least one input, output, noise factor, control factor, and error state for each system;

integrating a robust linkages tool to determine at least one failure mode for each system from the boundary diagram, the interface matrix, and the p-diagram [NEED TO EXPLAIN HOW], wherein each determined potential failure mode is categorized as one of the group of no function, partial/over function/degraded over time, intermittent function, and unintended function, and assigned an effect, cause of failure, and a recommended action;

recording a checklist based on the determined failure modes; and

recording a design verification plan from the checklist.

From: "John Buser" <JBUSER@brookskushman.com>
To: "Jiang, Siyuan (S.)" <sjiang@ford.com>
Date: 7/5/2003 1:26:28 PM
Subject: Patent Application

Siyuan,

Enclosed for your review is the first draft of the above-identified patent application including informal drawings. Please study the application in detail and note on the application any corrections, additions or deletions you feel are necessary to adequately describe the invention in such detail as to enable a person of ordinary skill in this technology to make and use the invention. When reviewing the application, please keep in mind that the application must also set forth what you believe to be the best mode or manner of making and using the invention. Please then return a marked-up draft or revised file to me at your earliest convenience.

We have a continuing duty to identify any prior art that an Examiner may consider to be material in deciding whether your invention is patentable. This duty continues throughout the pendency of the patent application, until it issues as a patent or is abandoned. If you are aware of any prior art, including patents, publications, or commercial activities, which you have not already identified, please forward it to me or call me to discuss it.

Please notice the numerous bolded protion requesting additional information. Please add what info you have. The object of these portions is clarification. You do not have to go to great lengths to fill in these areas. Put in what you'd like and we will live with the rest.

Please track your changes in Word and at least say no addition detail is need at the detail portions.

Please have you response to me by the end of the week. Please respond to this message to confirm its receipt. Please call me if you have questions, rather than e-mail, so that we can deal with the questions rapidly. Page me if I am not at my desk.

Once you have made your changes, I will finalize the application and send it to the rest of the Inventors for approval. I have intentionally not sent Bruce a copy as his review should only occur after we finalized the application.

Please give me a call if you have any questions.

Regards,

John R. Buser

Brooks & Kushman P.C.
1000 Town Center, 22nd Floor
Southfield, MI 48075
248-358-4400, -3351 (fax)
249-921-8121 (cell)

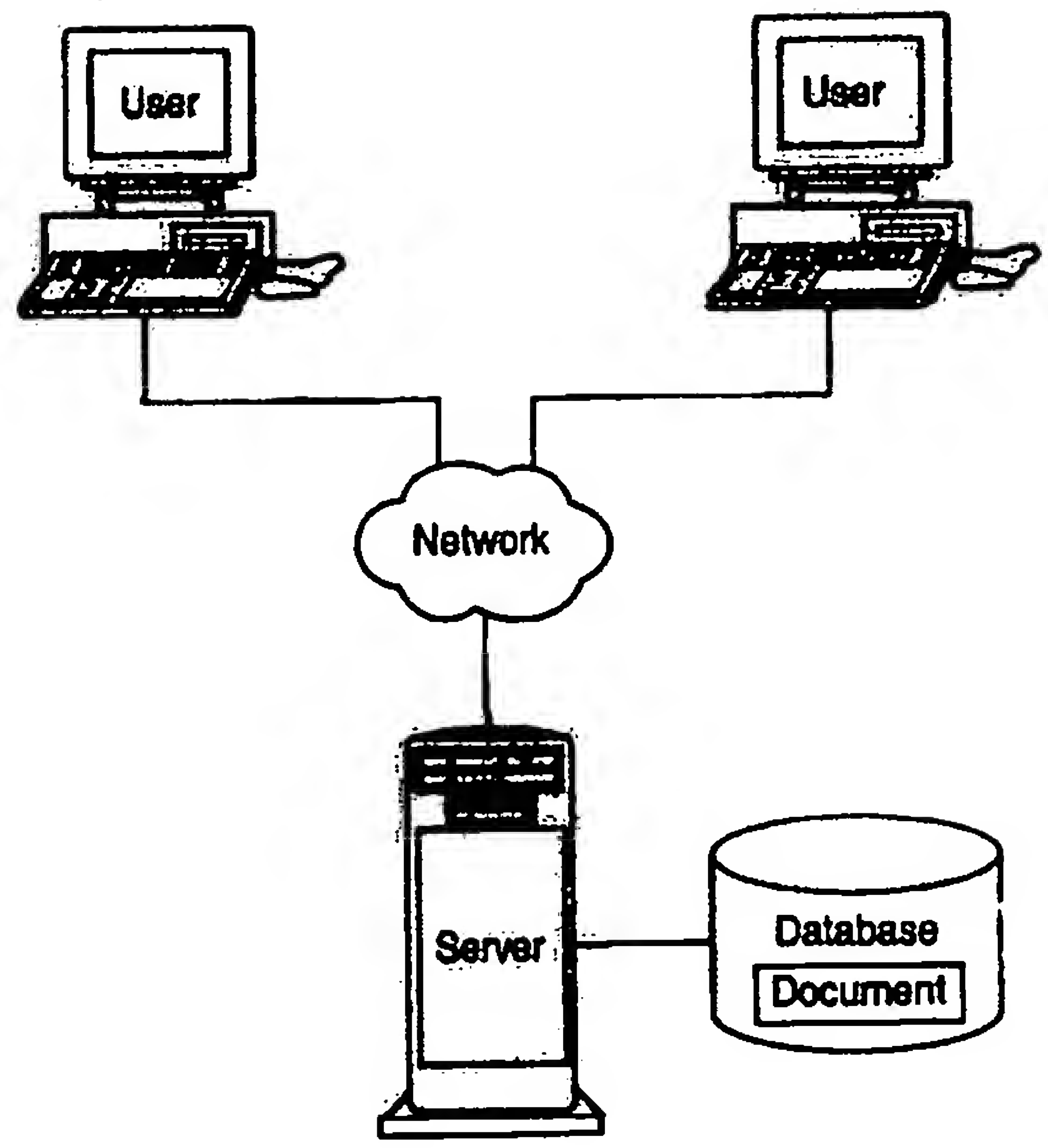


FIG.1

SAE J1739 Revised AIAG

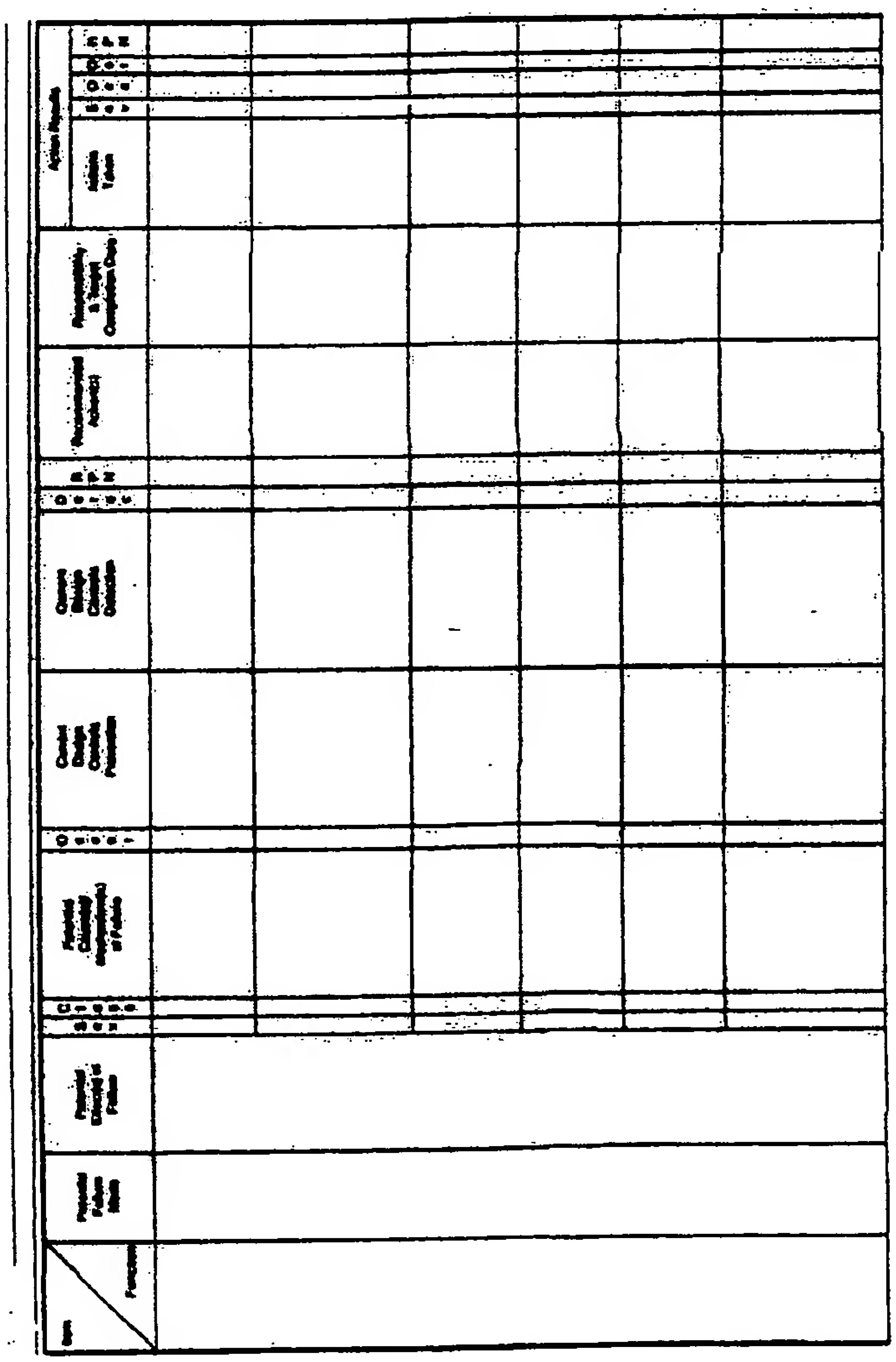


Fig 2

Pre-work

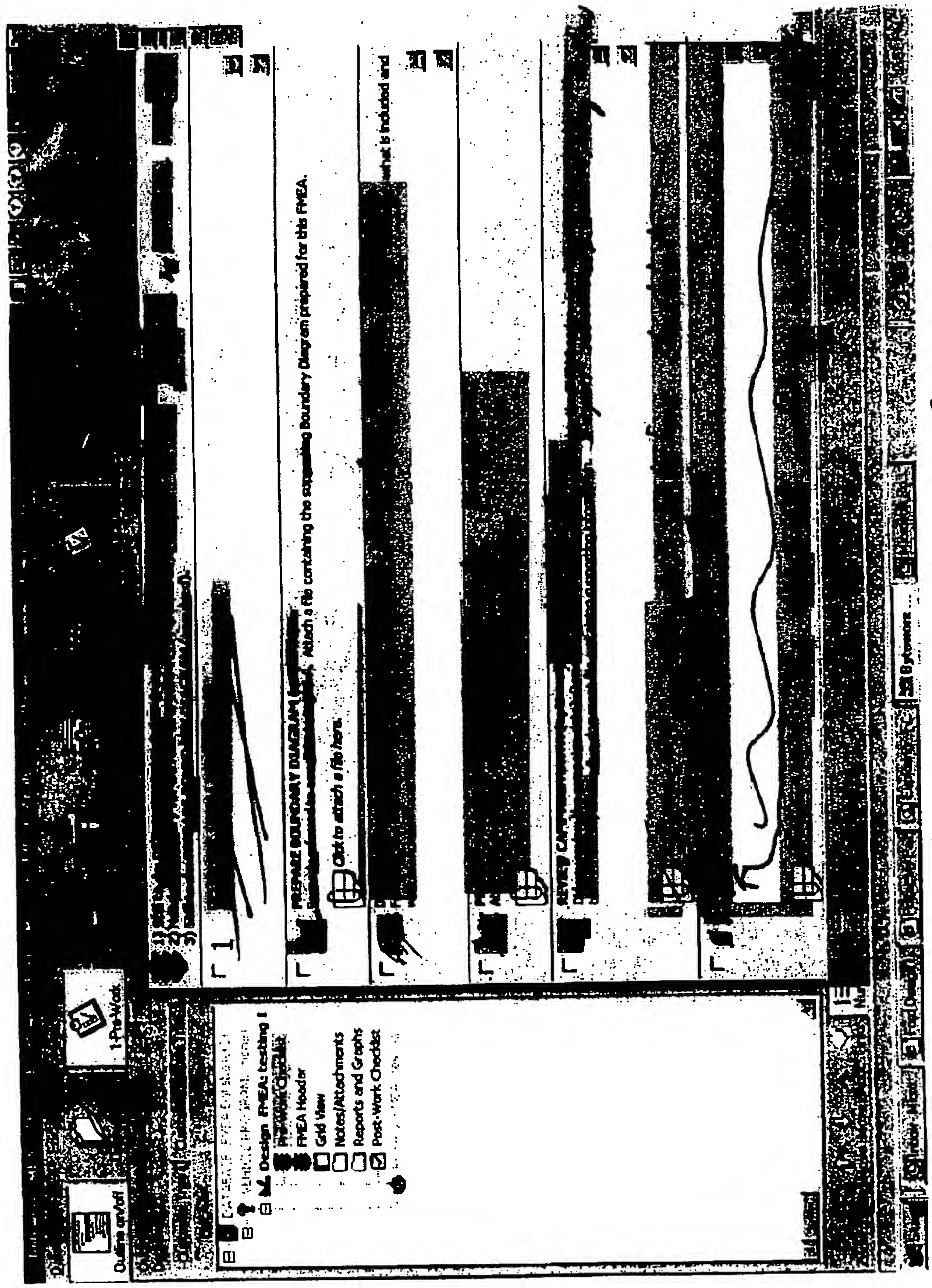


Fig 3

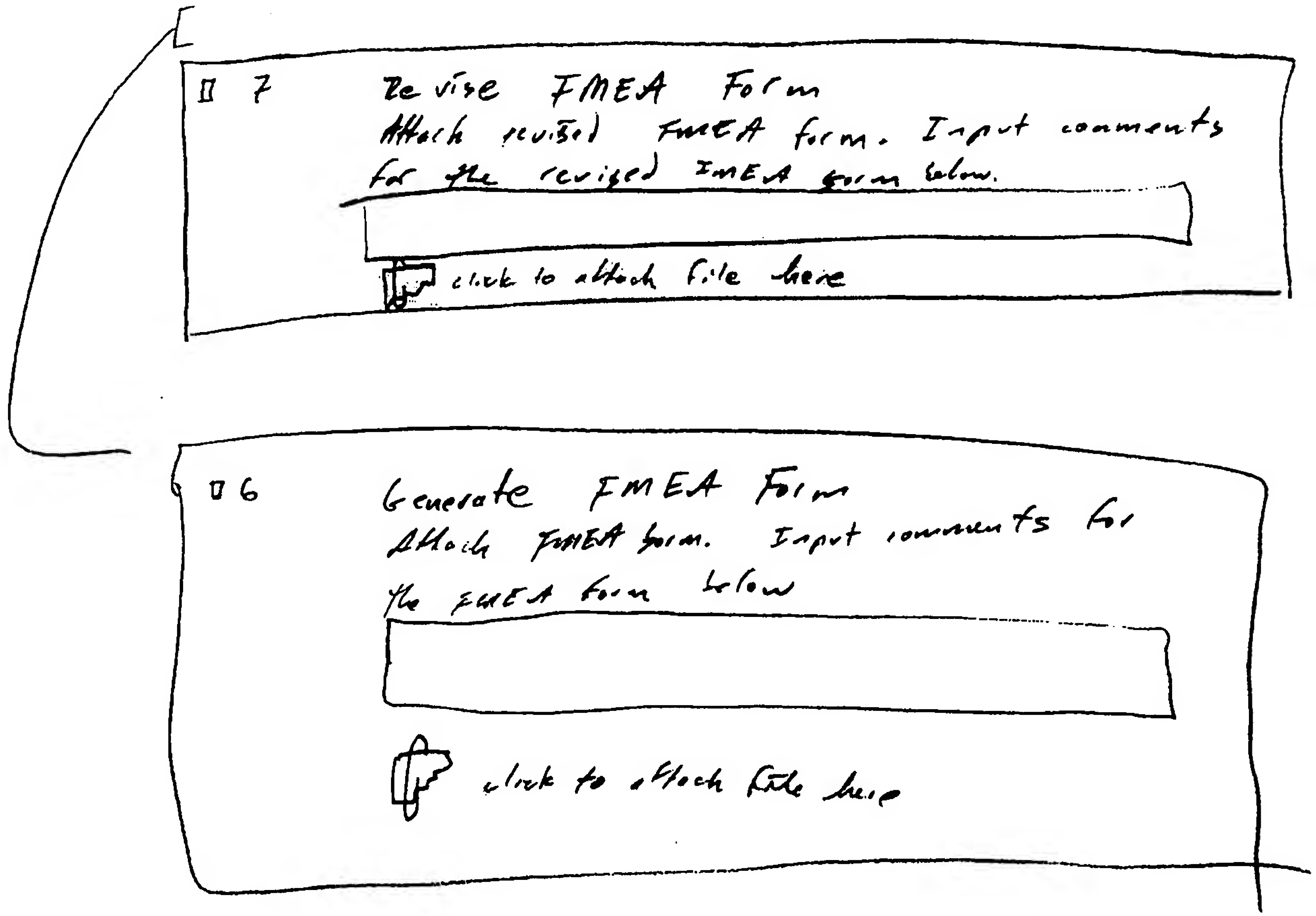
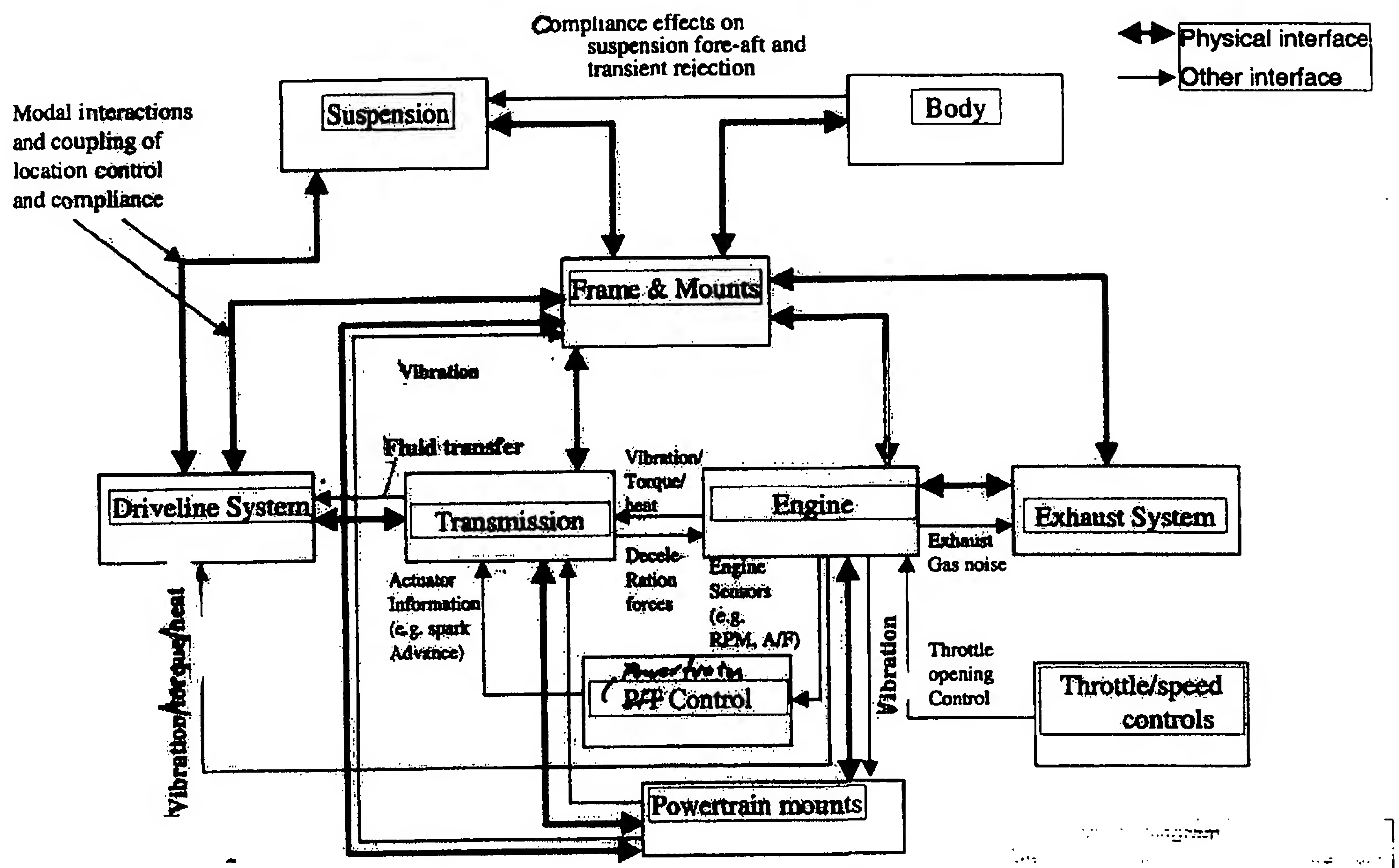

7
Revise FMEA Form
Attach revised FMEA form. Input comments for the revised FMEA form below.
click to attach file here
6
Generate FMEA Form
Attach FMEA form. Input comments for the FMEA form below
click to attach file here

Fig. 3 (cont.)

BOUNDARY DIAGRAM

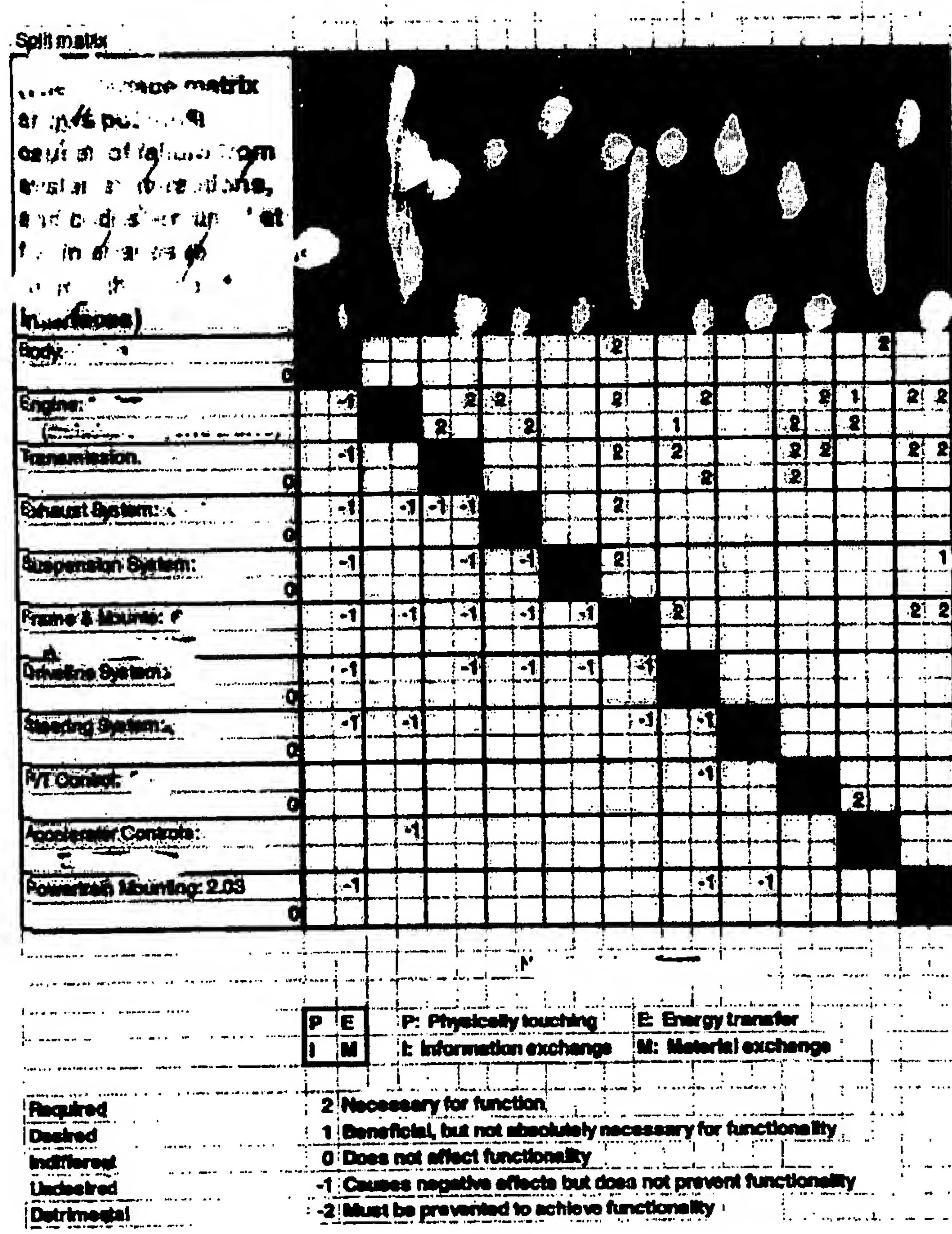
Automatic Transmission Shift Quality Example

Fig 4



~~Interface Matrix~~
~~A/T Shift Quality~~
~~Split Style~~

Fig 5.



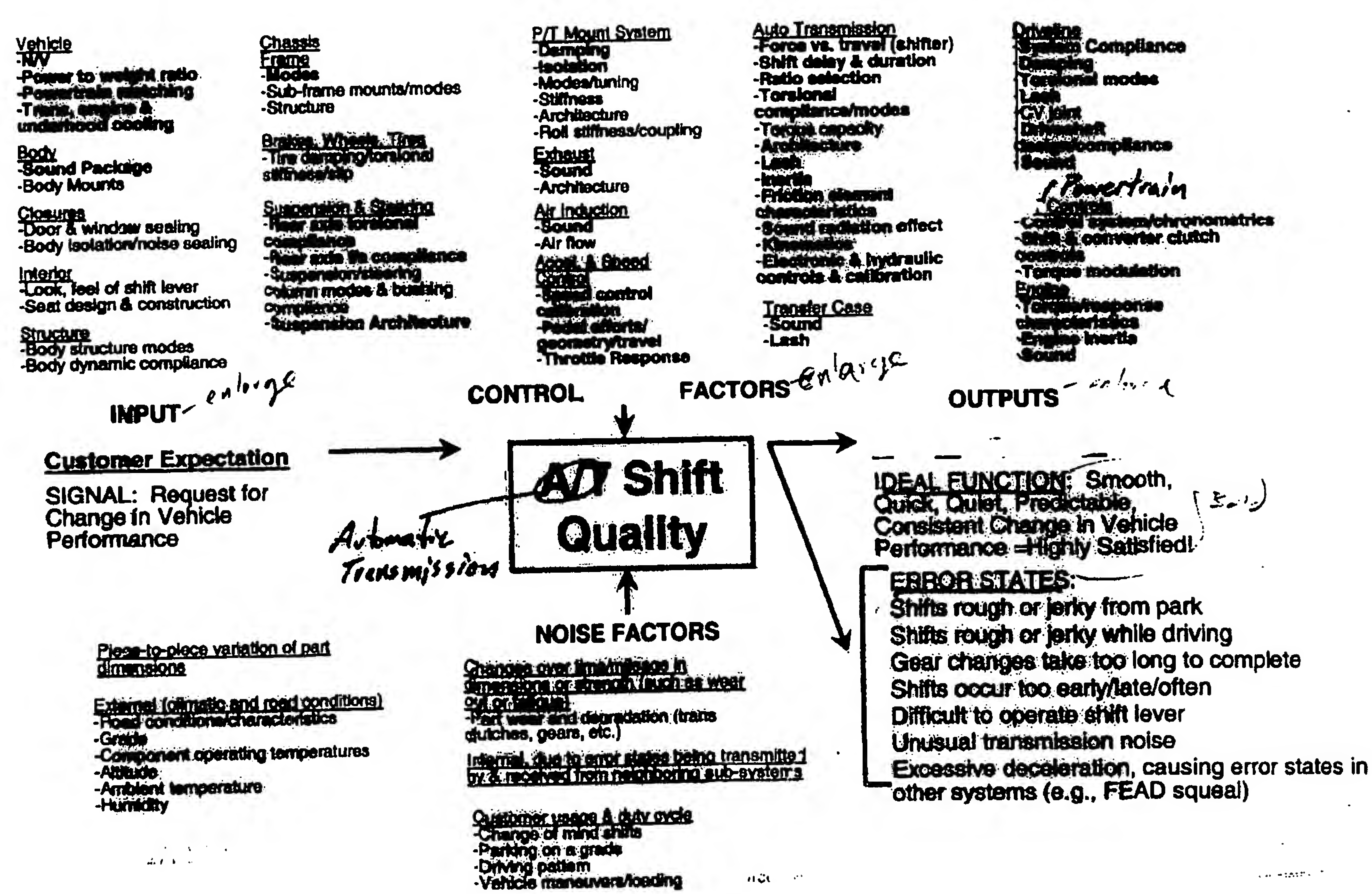
(don't need all these lines

13F

12/12/2002

Automatic Transmission Shift Parameter Diagram

Fig 6



SAE ... Revised ...

Srigwan, please fill in based only on data provided by Figures 3-5

Item / Function	Potential Failure Mode	Potential Effect(s) of Failure	Sev	Class	Potential Cause(s)/ Mechanism(s) of Failure	Occur	Current Design Controls Prevention	Current Design Controls Detection	Detec	RPN	Recommended Action(s)	Responsibility & Target Completion Date	Action Results: Actions Taken	Sev	Occ	Det	RPN

Fig #7

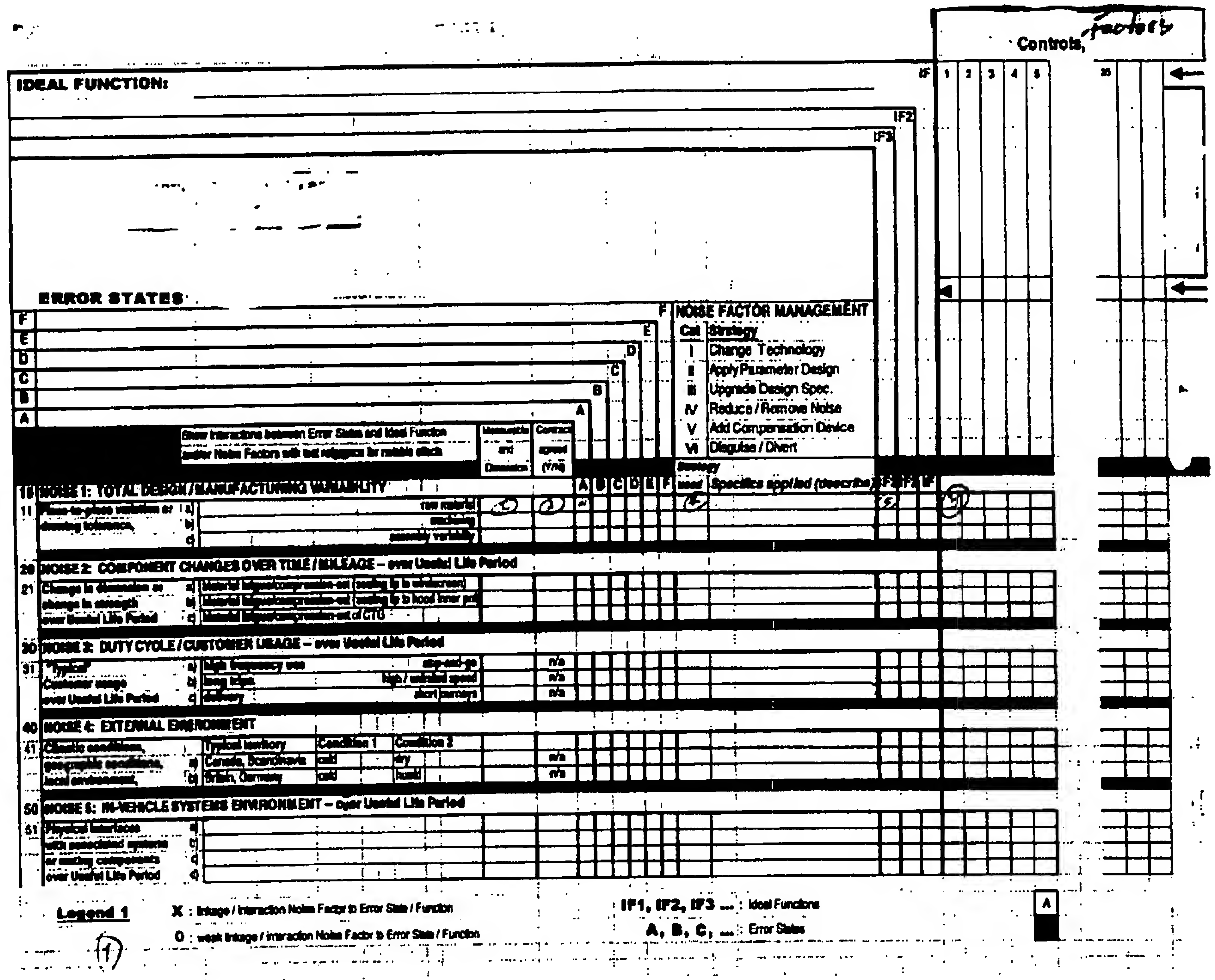

Controls, factors
IDEAL FUNCTION:
IF
IF2
IF3
1 2 3 4 5
ERROR STATES
F
E
D
C
B
A
NOISE FACTOR MANAGEMENT
Cat Strategy
I Change Technology
II Apply Parameter Design
III Upgrade Design Spec.
IV Reduce / Remove Noise
V Add Compensation Device
VI Disguise / Divert
Show interactions between Error States and Ideal Function and/or Noise Factors with text reference for notable effects
Measurable and Dimension
Contract agreed (Y/N)
Strategy used
Specifics applied (describe)
10 NOISE 1: TOTAL DESIGN / MANUFACTURING VARIABILITY
11 Piece-to-piece variation or drawing tolerance
raw material
machining
assembly variability
20 NOISE 2: COMPONENT CHANGES OVER TIME / MILEAGE – over Useful Life Period
21 Change in dimension or change in strength over Useful Life Period
Material fatigue/compression-set
Material fatigue/compression-set of CTG
30 NOISE 3: DUTY CYCLE / CUSTOMER USAGE – over Useful Life Period
31 "Typical" Customer usage over Useful Life Period
high frequency use
long trips
delivery
stop-and-go
high / unlimited speed
short journeys
n/a
40 NOISE 4: EXTERNAL ENVIRONMENT
41 Climatic conditions, geographic conditions, local environment
Typical territory
Condition 1
Condition 2
Canada, Scandinavia
Britain, Germany
cold
dry
humid
n/a
50 NOISE 5: IN-VEHICLE SYSTEMS ENVIRONMENT – over Useful Life Period
51 Physical interfaces with associated systems or mating components over Useful Life Period
Legend 1
X : linkage / interaction Noise Factor to Error State / Function
O : weak linkage / interaction Noise Factor to Error State / Function
IF1, IF2, IF3 ... : Ideal Functions
A, B, C, ... : Error States

Fig 8

Title

Method To Facilitate Failure Modes And Effects Analysis

Technical Field

The present invention relates to failure modes and effects analysis (FMEA). In particular, the present inventions relations to generating a FMEA form to indicate the FMEA.

Background Art

Failure Modes and Effects Analysis (FMEA) relates, in general, to a process used to determine the adequacy of current control process and the need to mitigate risks by making changes to the current control process. FMEA relates to any number of industries and applications. Each industry and application may have separate standards and criterion for the control processes used therein.

In the automotive industry, SAE specification J1739 details a number of standards and criterion for automotive related FMEAs. J1739 defines FMEA as a systemized group of activities intended to: (a) recognize and evaluate the potential failure of a product/process and its effects; (b) identify actions which could eliminate or reduce the chance of the potential failure occurring; and (c) document the process. It is complementary to the process of defining what a design or process must do to satisfy the customer.

Generating a FMEA form to indicate the FMEA, whether the FMEA is conducted with respect to the J1739 specification or another specification, tends to be a difficult process in that most FMEA specifications fail to provide a robust method for generating the FMEA form.

Summary Of The Invention

The present invention overcomes the above-identified deficiencies with a robust method for generating a failure modes and effects analysis (FMEA) form. The method comprises providing a graphical user interface to display a sequential order for creating a number of graphical representations. The graphical representations are created to pictorially diagram component interactions of components comprising the analyzed system. The sequential order insures the graphical representation are created according to a predefined sequence of steps. The FMEA form is then generated after completing the steps.

In the automotive industry, a FMEA form typically comprises a number of data entry fields. The entry field are filled in by the FMEA analyst to indicate the results of the FMEA. In this manner, the FMEA form indicates the FMEA. The FMEA form dictated by SAE specification J1739 includes an item/function textual entry, a potential failure mode textual entry, a potential effects of failure textual entry, a severity numerical

entry, a classification textual entry, a potential cause of failure textual entry, a frequency of occurrence numerical entry, a current designs controls prevention textual entry, a current design controls detection textual entry, a detection numerical entry, a risk prioritization numerical entry, a recommended action textual entry, a responsibility textual entry, an actions taken textual entry, a revised severity numerical entry, a revised frequency of occurrence numerical entry, a revised detection numerical entry, and a revised risk prioritization numerical entry. The present invention assists the FMEA analyst in analyzing the system for the purpose of inputting the data.

One aspect of the present invention relates to utilizing graphical representations of component interactions to facilitate generating the FMEA form. The component interactions relate to the interactions between components comprising a system that the FMEA covers. The graphical representations of the component interactions provide a pictorial diagram of component interactions for one or more components comprising the system. The graphical representations provide the FMEA analyst with a robust visual means to determine potential failure modes within the system.

One aspect of the present invention relates to a sequential order for providing the graphical representations of the component interactions. The sequential order comprises steps for completing a number of graphical representations which the FMEA analyst can use to facilitate generating the FMEA form. The sequential order of the steps can comprise, in order, providing a boundary diagram graphical representation, providing an interface matrix diagram graphical representation, and providing a parameter diagram graphical representation. The sequential order is robust in that each graphical representation builds upon a previous graphical representation to facilitate generating the FMEA form.

One aspect of the present invention relates to a computer-readable medium. The computer-readable medium is programmed to facilitate generating the FMEA form. The computer-readable medium displays a sequential order for creating a number of graphical representations of component interactions by completing in order a number of steps. Once completed, the computer-readable medium is programmed to receive the graphical representations to facilitate generating the FMEA form. The computer-readable medium is preferably programmed to indicate whether the graphical representations are received according to the sequential order of completion. The indications provide robustness in that the FMEA analyst can follow the indications when creating the graphical representations.

Brief Description Of The Drawings

Detailed Description

FIGURE 1 illustrates a system for failure modes and effects analysis (FMEA). The system comprises one or more user computers connecting through a network to a network server computer. The network computer connects to a database for storing and retrieving data. The data stored and retrieved by the network computer can include electronically accessible documents.

The network computer includes a processor (not shown) for executing computer-readable instructions. The network computer can execute instructions from a computer-readable medium, such as a hard-drive or compact disk.

FIGURE 2 illustrates an exemplary FMEA form. The FMEA form shown in Figure 2 relates to a Society of Automotive Engineers (SAE) specification J1739. As such, this description relates to the automotive industry and conducting FMEAs according to J1739. The scope of the present invention, however, is not limited to the automotive industry or SAE specification J1739. In contrast, the present invention relates to any number of industries which conduct FMEAs.

In the automotive industry, the FMEA form typically comprises a number of data entry fields. The entry field are filled in by the FMEA analyst to indicate the results of the FMEA. In this manner, the FMEA form indicates the FMEA. The FMEA form dictated by SAE specification J1739 include an item/function textual entry, a potential failure mode textual entry, a potential effects of failure textual entry, a severity numerical entry, a classification textual entry, a potential cause of failure textual entry, a frequency of occurrence numerical entry, a current designs controls prevention textual entry, a current design controls detection textual entry, a detection numerical entry, a risk prioritization numerical entry, a recommended action textual entry, a responsibility textual entry, an actions taken textual entry, a revised severity numerical entry, a revised frequency of occurrence numerical entry, a revised detection numerical entry, and a revised risk prioritization numerical entry. The FMEA analyst inputs data for each entry to generate the FMEA form.

FIGURE 3 illustrates a graphical user interface provided by the network computer. The graphical user interface facilitates generating the FMEA form by providing instructions and receiving inputs. In this manner, the FMEA analyst can view the graphical user interface to receive instructions for conducting the FMEA and for inputting data to the graphical interface for use in generating the FMEA. The graphical user interface can be a web page, or other medium. In particular, the graphical user interface can reside in a computer-readable program which can be loaded on one of the user computers instead of being accessed by the user computers through the network computer.

The graphical user interface displays a sequential order for creating a number of graphical representations. The graphical representations are created to pictorially diagram component interactions. The graphical representations of the component interactions provide a pictorial diagram of component interactions for one or more components comprising the system. The graphical representations provide the FMEA analyst with a robust visual means to determine potential failure modes within the system. The sequential order of providing the graphical representations insures the graphical representation are created according to a predefined sequence of steps.

The graphical user interface includes a process indicator to indicate completion of each graphical representation in the sequential order. The process indicator, as shown in Figure 3, relates a traffic light indicator. The traffic light indicator includes one or more next step descriptions. The next step descriptions indicate which step is to be performed next according to the sequential order of steps.

The process indicator begins with a step. Step relates to preparing a boundary diagram. FIGURE 4 illustrates the boundary diagram. The boundary diagram

provides a pictorial diagram of component interactions comprising the components in the analyzed system. As shown in Figure 4, the components relate to the components which affect an automatic transmission shift quality system. The boundary diagram sets the scope of the FMEA by identifying the relevant components which affect the system.

The relevant components are those components having a physical or a non-physical interaction with the system. A physical interaction comprises ________. A non-physical interaction comprises ___________. **[Siyuan, please add detail]**

The automatic transmission shift quality system relates to an automobile. The components relevant to analyzing the system comprise a suspension component, a body component, a frame & mount component, a driveline system component, a transmission component, an engine component, a exhaust component, a powertrain control component, a throttle/speed control component, and a powertrain mounts component.

An interaction line connects interacting components. The interaction line comprises an arrow at both ends of the interaction line (double-arrow) if the interaction is a physical interaction, and the interaction line comprises only an arrow at one end of the interaction line (single arrow) if the interactions is a non-physical interaction. In the case of non-physical interactions, a textual description details the non-physical interaction.

For example, an interaction takes place between the engine component and the exhaust system component. A physical interaction is shown with a double-arrow and a non-physical interaction is shown with a single arrow. A description for the non-physical interaction is shown. The direction of the single arrow of the non-physical interaction indicates the engine component delivers the non-physical interaction to the receiving exhaust gas system component, i.e., the single arrow points in the direction of the receiving component.

To determine the components and the interaction of the components shown in Figure 4, the FMEA analyst would brainstorm to determine the various components comprising the analyzed system. Additional team members can also be included to assist the FMEA analyst. The network computer and the user computers provide remote access such that multiple persons can be involved with the FMEA from different locations. This is achieved by each member accessing the graphical user interface and uploading and retrieving information to and from the graphical user interface.

The boundary diagram forces the FMEA analyst to think visually by requiring the FMEA analyst to provide a pictorial representation of the component interactions. This is an advantageous first step to insure the FMEA analyst identifies a scope of the FMEA and the components affecting the scope. In addition, the FMEA analyst if further forced to think visually by drawing the interaction lines between each interaction component. This addresses a common problem of including components in the system while at the same time failing the detail the interaction of the components with other components. A component should be kept out of the boundary diagram unless it interacts with another component in the system. Components which are not so matched up are easily identified because no interaction line connect the component to another component. Still further, the textual descriptions for the non-physical interactions provides addition visual support for understanding the interactions.

The process indictor tracks completion of each step by tracking receipt of the corresponding graphical representations. Preferably, the tracking can be done by clicking on a box provided next to each step. As shown in Figure 3, the process indicator provides a graphical description. The graphical description changes as each step is completed. Initially, the graphical description states the following: "1) Still to do: prepare boundary diagram" and "2) Next to do: prepare interface matrix diagram." This means the process indicator has not registered receipt of the boundary diagram. Once the boundary diagram is received, the graphical description will change and state: "1) Still to do: prepare interface matrix diagram" and "2) Next to do: prepare parameter diagram."

In this manner, the process indicator indicates what is done, what is being worked on, and what is to be done next. Even a first-time FMEA analyst can follow the steps to generate the FMEA form. Preferably, the process indicator conducts a brief computerized check of the boundary diagram to make sure each component includes at least one interaction line, but such enhanced functionality is not required.

A step begins after the process indicator indicates receipt of the boundary diagram. Step relates to preparing an interface matrix diagram. FIGURE 5 illustrates the interface matrix diagram. The interface matrix diagram provides a strength for each interaction provided by the boundary diagram. In this manner, the interface matrix builds upon the data included in the boundary diagram.

The interface matrix includes a vertical axis with each component listed and a horizontal axis with each component listed. Boxes are place at each interaction of the vertical axis and the horizontal axis. The boxes are four quadrant boxes as indicated with the phantom lines. A numerical entry is made in each box to indicate the strength of the interaction between the component connected to the box.

A legend indicates a meaning for the numerical entry within each box. A value of "2" indicates the interaction as one of necessary to functionality, a value of "1" indicates the interaction as one of beneficial but not absolutely necessary for functionality, a value of "0" indicates the interaction as one of not necessary to functionality, a value of "-1" indicates the interaction as one of causing negative effects but not preventing functionality, and a value of "-2" indicates the interaction as one of requiring prevention to achieve functionality.

The positioning of the value within the box provides additional meaning. The positioning of a numerical entry in a first quadrant indicates physical touching, a second quadrant indicates energy transfer, a third quadrant indicates information exchange, and a fourth quadrant indicates material exchange. The positioning of the numerical entry provides a common description of a type of interaction. This is advantageous to generalize the various interactions provided by the boundary diagram, as there can be numerous non-physical interactions with different descriptions, as shown in Figure 4. Preferably, more than one numerical entry can be include within each box with a total of up to four entries.

For example, the interaction between the engine component and the exhaust component includes a numerical entry for each interaction shown in the boundary diagram for these components. As such, two numerical entries are required. A first entry comprises a numeral "2" and the first quadrant to indicate a strength of interaction as physically touching and necessary to functionality. A second entry comprises a numeral "2" and the fourth quadrant to indicate a strength of interaction as material exchange and

necessary to functionality.

The interface matrix advantageously builds upon the boundary diagram by forcing the FMEA analyst to evaluate the strength of each interaction provided by the boundary diagram. This provides a second check of the interactions determined by the boundary diagram. Moreover, the visual representation of the strength value provides for quick analysis on a global level so that the FMEA analyst and team member can brainstorm potential failure modes.

A step begins after the process indicator indicates receipt of the interface matrix diagram. Step relates to preparing a parameter diagram. FIGURE 6 illustrates the parameter diagram. The parameter diagram provides textual descriptions of noise factors, inputs, design controls, and outputs to indicate influences of potential failure for the system. This data is based in part upon interactions provided by the boundary diagram and the strength of the interaction provided by the interface matrix. In this manner, the parameter diagram builds upon the data included in the boundary diagram and the interface matrix.

The parameter diagram ties together information provided by the boundary diagram and the interface matrix diagram into a format that FMEA analyst can use to generate the FMEA form. The parameter diagram visually represents inputs and outputs of the system along with the noise factors and control factors.

The inputs relate to desired aspects of the system to be analyzed by the FMEA. The input is commonly referred to with one or more signals. As shown, the input here relates to a request for change in vehicle system. This means ______. Other inputs can also be analyzed.

The output comprises ideal function and error states. Unlike the inputs, the outputs are predefined fields the FMEA analyst must fill in to complete the parameter diagram. The ideal functions relate to desired output of the system if all component interactions functioned as expected. The error states relate to potential errors in the output of the system due to the interactions of components.

The error states are determined by brainstorming potential causes of failure based on the boundary diagram, the interface matrix, and the noise factors and control factors of the parameter diagram.

The noise factors indicate influences on the input that can lead to disruption of the ideal function and result in the error states. The parameter diagram includes predefined noise factors for place-to-place variation, external conditions of usage, internal conditions of usage and changes in dimension. These noise factors are inputs the FMEA analyst must analyze to indicate influences of potential failure for the system. Additional noise factors, however, can be included.

The control factors relate to the various quality checks and testing procedures done to the components. The control factors are intended to prevent the noise factors from producing the error states or discover error prior to delivery. The control factors can be quality testing procedures, design parameters, and other measures.

The visual representation of the parameter diagram tying together each of the inputs, noise factors, controls factors, ideal functions, and error states presents the FMEA analysis with a pictorial diagram of many of the features which can potential cause failures. The parameter diagram leverages off of the data provided by the boundary diagram and the interface matrix diagram. The completion of the boundary diagram and

the interface matrix diagram prior to completing the parameter diagram insures each component interaction is characterized and the strengths of the interactions are identified and included when determining the error states.

Additional fields can be included with the parameter diagram. The additional fields can provide other areas to inquire into to determine other potential failure modes. For example, a knowledge base or a customer feedback base could be generated and a corresponding field entered into the parameter diagram. The FMEA analyst would then enter a corresponding control factor, error state, ideal function, or noise factor for the additional fields. Preferably, the presentation of the additional data will lead to discovery of other potential failure modes.

A step begins after the process indicator indicates receipt of the parameter diagram. Step relates to inputting data into the various field entries of the FMEA form. FIGURE 7 illustrates the FMEA form after inputting the entries. The FMEA form is created by each of entering the item/function textual entry based upon reviewing the boundary diagram and the parameter diagram, entering the potential effects of failure textual entry based upon reviewing the parameter diagram, entering the potential cause of failure textual entry based on reviewing interface matrix diagram and the parameter diagram, entering the current design controls prevention based on reviewing the parameter diagram, entering the current design controls detection textual entry based on reviewing the parameter diagram, and entering the recommended action textual entry base on reviewing the parameter diagram.

[Siyuan, may want more detail here. This is the focus of the application and we want to detail the process of filling in the FMEA form]

A step begins after the process indicator indicates receipt of the FMEA form. Step relates to generating an interface checklist diagram. The interface checklist diagram is used to check the entries made to the FMEA form. FIGURE 8 illustrates the interface checklist diagram.

The interface checklist diagram includes a number of fields. The fields can be manually entered or the graphical user interface can import entries from one or more of the boundary diagram, the interface matrix diagram, and the parameter diagram. Preferably, the graphical user interface automatically imports data for each noise factor, each error state, each ideal function, and each design control from the parameter diagram.

For each noise factor, checkmarks are made in each applicable field in the checklist. A measurable and dimension field is checked if the noise factors includes a parameter has a measurable dimension. The measurable dimension can be a physical dimension or a qualitative dimension. The checkmark indicates some unbiased test can be made with respect to the dimension.

A contract agreed field relates to whether there is any agreement in place for the measurable dimension. The agreement would specify a range of tolerances or other limitation of the measurable dimension. **[Detail]**

Each error state receives a checkmark if it affects the noise factors. Fields A, B, C, D, E, and F are used to designate the error state interface with the noise factors. The noise factor can receive more than one error state checkmark if more than one error state affects the noise factor. Advantageously, the error state checkmarks force the FMEA analyst to make sure all the error states are assigned to at least one of the noise factors. In this manner, the noise factors producing the error states can be checked. The

FMEA formed is check against the error state checkmarks to insure a cause (noise factor) of each error state is identified.

Noise factor management fields are provided to indicate how the FMEA analyst plans to management the noise factors. As the noise factors influence failures and the generation of the error states, it is advantageous to assign a noise factor management strategy to each noise factor. The assigned strategies are check against the FMEA form to insure the FMEA form includes similar management. The FMEA form is revised if it lacks the management strategy.

The noise factor management strategies are designated with a roman numeral checkmark. I indicates change technology required to manage the noise factor. II indicates a need to apply a parameter design control to mange the noise factor. III indicate a need to upgrade a design specification to manage the noise factor. IV indicates a need to reduce or remove noise from to manage the noise factor. V indicates a need to add a compensation device to manage the noise factor. VI indicates a need to disguise or divert to manage the noise factor. **[Detail – unclear]**

Ideal function fields are provide to check which noise factors are affecting the ideal functions. The effect of the noise factors on the ideal functions is important as the ideal functions are the desirable output of the system. As such, the noise factors influencing the ideal functions need to be associated with the affected ideal functions and checked against the FMEA form to insure the FMEA form addresses the problem. The FMEA form is revised if it fails to take into account a noise factor which affects one of the ideal functions.

Control factor fields are provided to check which controls factors are applicable to each noise factor. A checkmark matches the control factor with the corresponding noise factor. Each noise factor should receive a checkmark if a control factor is assigned to the noise factor. The FMEA form is matched against the control factor checkmarks to insure each noise factor is addressed. The FMEA form is revised if it fails to address each noise factor with one or more control factors.

A checkmark legend indicates more detail for the checkmarks. X's can be used to indicate strong linkages and O's can be used to indicate weak linkages. These visual representation can enhance the ability of the FMEA analyst understand the effects of the various noise factors.

While the best mode for carrying out the invention has been described in detail, those familiar with the art to which this invention relates will recognize various alternative designs and embodiments for practicing the invention as defined by the following claims. The sequential order disclosed above is not intended to limit the scope of the present invention. In contrast, a non-sequential order could be used and the use of such a non-sequential order is within the scope and contemplation of the present invention.

Claims

1.1 A computer-implemented method to facilitate failure modes and effects analysis (FMEA) of one or more components of a system, wherein an FMEA form is generated to indicate the FMEA, the method comprising:

displaying with a graphical user interface used by a computer a sequential order of completion of steps for a number of graphical representations which are to be completed by an FMEA analyst and received by the graphical user interface in sequential order to facilitate generating the FMEA form; and

receiving the graphical representations according to the sequential order of completion, wherein receiving the graphical representations comprises receiving a pictorial diagram of component interactions for one or more components comprising the system such that a visual display of the component interactions is received to facilitate generating the FMEA form, and wherein a first graphical representation is received and each subsequently received graphical representation is completed based in part upon the visual display provided by the first graphical representation such that each graphical representation builds upon the first graphical representation to facilitate generating the FMEA form.

2.1 The method of claim 1 further comprising displaying a process indicator to indicate completion of each graphical representation in the sequential order, wherein the process indicator tracks receipt of each graphical representation for use in indicating completion of the graphical representation.

3.1 The method of claim 1 wherein receiving the first graphical representation comprises receiving a boundary diagram to pictorially diagram the component interactions of the components comprising the system such that the boundary diagram facilitates generating the FMEA form, wherein the boundary diagram identifies physical and non-physical interactions between the components comprising the system.

4.1 The method of claim 3 further comprising receiving textual inputs naming each one of the components comprising the system and graphically displaying the names with an interaction of the components, wherein the interaction is graphically displayed by drawing an interaction line between each component to pictorially diagram the system interactions.

5.1 The method of claim 4 further comprising indicating the interaction line with double arrows to indicate a physical interface and a single arrow to indicate non-physical interaction, wherein each non-physical interaction includes a textual description.

6.1 The method of claim 3 further comprising receiving an interface matrix diagram after receiving the boundary diagram to pictorially diagram the component interactions of the components comprising the system such that the interface matrix is used in combination with the boundary diagram to facilitate generating the

FMEA form, wherein the interface matrix diagram includes interface valuation data which identifies a strength for each interaction determined by the boundary diagram.

7.1 The method of claim 6 further comprising receiving a numerical strength input for each interaction to indicate the strength of the interaction.

8.1 The method of claim 7 further comprising indicating the numerical strength input with a value indicating the strength for each interaction as one of necessary to functionality, beneficial but not absolutely necessary for functionality, not necessary to functionality, causing negative effects but not preventing functionality, and requiring prevention to achieve functionality.

9.1 The method of claim 8 wherein the interface matrix includes a four quadrant box for each component comprising the system and arranges the components within the interface matrix such that one box is provided to match each component with every other component comprising the system, and wherein the method further comprises positioning the numerical strength input within one quadrant of the four quadrants of the four quadrant boxes to indicate a type of interaction for the component.

10.1 The method of claim 9 further comprising positioning the numerical strength input in a first quadrant to indicate physical touching, a second quadrant to indicate energy transfer, a third quadrant to indicate information exchange, and a fourth quadrant to indicate material exchange.

11.1 The method of claim 6 further comprising receiving a parameter diagram after receiving the boundary diagram and the interface matrix diagram to pictorially diagram the component interactions of the components comprising the system such that the parameter diagram is used in combination with the boundary diagram and the interface matrix to facilitate generating the FMEA form, wherein the parameter diagram includes textual descriptions of noise factors, inputs, design controls, and outputs to indicate influences of potential failure for the system based on the interactions provided by the boundary diagram and the strength for each interaction provided by the interface matrix.

12.1 The method of claim 11 further comprising receiving noise factors for the group comprising place-to-place variation, external conditions of usage, internal conditions of usage and changes in dimension to indicate influences of potential failure for the system.

13.1 The method of claim 12 further comprising receiving outputs from the group of ideal function and errors states to indicate influences of potential failure for the system.

14.1 The method of claim 13 wherein the FMEA form includes an item/function textual entry, a potential failure mode textual entry, a potential effects of failure textual entry, a potential cause of failure textual entry, a current designs controls

prevention textual entry, a current design controls detection textual entry, and a recommended action textual entry, and the method further comprises generating the FMEA form by each of entering the item/function textual entry based upon reviewing the boundary diagram and the parameter diagram, entering the potential effects of failure textual entry based upon reviewing the parameter diagram, entering the potential cause of failure textual entry based on reviewing interface matrix diagram and the parameter diagram, entering the current design controls prevention based on reviewing the parameter diagram, entering the current design controls detection textual entry based on reviewing the parameter diagram, and entering the recommended action textual entry base on reviewing the parameter diagram.

15.1 The method of claim 14 further comprising revising the generated FMEA form based on receiving an interface checklist diagram, wherein the interface checklist diagram includes noise factors from the parameter diagram and requires a number of checkmarks for each noise factor in one or more categories from the group comprising the error states provided by the parameter diagram, noise factor management strategies, the ideal functions provided by the parameter diagram, and design controls provided by the parameter diagram such that the FMEA form is revised for each noise factor which fails to include one or more checkmarks.

16.1 A computer-implemented method to generate a failure modes and effects analysis (FMEA) form for one or more components of a system, the method comprising:

providing a graphical user interface for use with a computer, wherein the graphical user interface provides a number of data entry fields for an item/function textual entry, a potential failure mode textual entry, a potential effects of failure textual entry, a severity numerical entry, a classification textual entry, a potential cause of failure textual entry, a frequency of occurrence numerical entry, a current designs controls prevention textual entry, a current design controls detection textual entry, a detection numerical entry, a risk prioritization numerical entry, a recommended action textual entry, a responsibility textual entry, an actions taken textual entry, a revised severity numerical entry, a revised frequency of occurrence numerical entry, a revised detection numerical entry, and a revised risk prioritization numerical entry to be inputted with data for generating the FMEA form;

displaying with the graphical user interface a sequential order of completion of steps for a number of graphical representations which are to be completed by an FMEA analyst and received by the graphical user interface in sequential order to facilitate generating the FMEA form;

receiving the graphical representations according to the sequential order of completion, wherein receiving the graphical representations comprises receiving a pictorial diagram of component interactions for one or more components comprising the system such that a visual display of the component interactions is received to facilitate generating the FMEA form, and wherein a first graphical representation is received and each subsequently received graphical representation is completed based in part upon the visual display provided by the first graphical representation such that each graphical representation builds upon the first graphical representation to facilitate generating the

FMEA form; and

inputting data into each of the entries provided by the graphical user interface after receiving the graphical representation according to the sequential order of completion.

17.1 A computer-implemented method to facilitate failure modes and effects analysis (FMEA) of one or more components of a system, wherein an FMEA form is generated to indicate the FMEA, the method comprising:

displaying with a graphical user interface used by a computer a sequential order of completion of steps which are to be completed by an FMEA analyst in sequential order to facilitate generating the FMEA form;

completing the steps in sequential order; and

generating the FMEA form upon completion of a last step.

18.1 The method of claim 17 wherein the sequential order of completion of steps comprises in order providing a boundary diagram graphical representation, providing an interface matrix diagram graphical representation, and providing a parameter diagram graphical representation, wherein providing the graphical representations comprises providing a pictorial diagram of component interactions for one or more components comprising the system such that a visual display of the component interactions is provided to facilitate generating the FMEA form, and wherein the boundary diagram graphical representation is provided, the interface matrix diagram graphical representation is provided after providing the boundary diagram graphical representation and based in part upon the visual display provided by the boundary diagram graphical representation, and the parameter diagram graphical representation is provided after providing the boundary diagram graphical representation and the interface matrix diagram graphical representation such that each graphical representation builds upon the boundary diagram graphical representation to facilitate generating the FMEA form.

19.1 A computer-readable medium facilitate failure modes and effects analysis (FMEA) of one or more components of a system, wherein an FMEA form is generated to indicate the FMEA, the computer-readable medium programmed to:

display a sequential order of completion of steps for a number of graphical representations of component interactions which are to be completed by an FMEA analyst and received by the graphical user interface in sequential order to facilitate generating the FMEA form; and

indicate whether the graphical representations are received according to the sequential order of completion.

20.1 The computer-readable medium of claim 19 programmed to receive a boundary diagram, an interface matrix diagram, a parameter diagram, and an interface checklist diagram.